TOMAHAWK®

HELICOPTER FLIGHT SIMULATION

DIGITAL INTEGRATION

JOYSTICK REQUIRED

It took 11 years to develop the first Advanced Attack Helicopter (AAH) for the U.S. Army, (the first prototype flew on 30th September 1975) and the Hughes AH-64A Apache has surpassed all expectations.

The very appearance of this monstrous machine is calculated to instill fear into the hearts of the enemy. Its performance is equally terrifying.

The Apache is first and foremost a formidable fighting machine. It can fly low over the ground at great speed yet with enough stealth to surprise the enemy with a massive bombardment. Its Hellfire anti-tank missiles are guided by laser beams for extraordinary accuracy. It can operate by day or night and in adverse weather conditions, and is designed to protect the 2-man crew from the most arduous battle conditions. Some really special and unique features include a 'Black Hole' which is an IR suppression system in the exhaust to protect against IR-homing missiles. A truly futuristic touch is the Integrated Helmet and Display Sight System (IHADSS) which, amongst other things, permits both pilots to point weapons simply by looking at the target. The delivery of the first Apaches to the U.S. Army in 1984 has given them fighting machines described as possibly "more revolutionary than the Germans' use of tanks and dive bombers in the Blitzkrieg warfare of World War II".

AH-64A APAC

SPECIFICATION
Accommodation
Co-pilot/gunner and pilot in tandem, in armour protected seats.

Fuel Capacity
375 US gal (1 419l) in 2 crash resistant fuel cells in the fuselage. 4 external 204 US gal (733-1) tanks on weapons pylons for ferry flying.

Armament
16 Rockwell AGM-114A Hellfire antitank missiles.
1 Hughes M23 0A1 30mm Chain Gun automatic cannon plus 1,200 rounds.
4 19-round pods of 2¾" (70mm) rockets.

Power
Two General Electric T700-GE-701 turboshaft engines. Each rated at 1,695 shp (1 264 kW) at sea level, ISA, for take-off, with a contingency rating of 1,723 shp (1 286 kW).
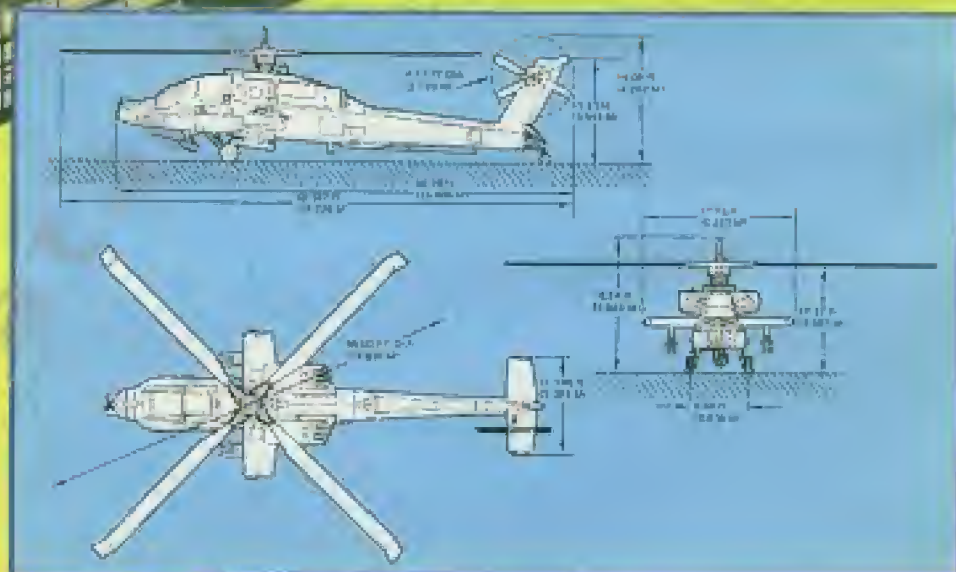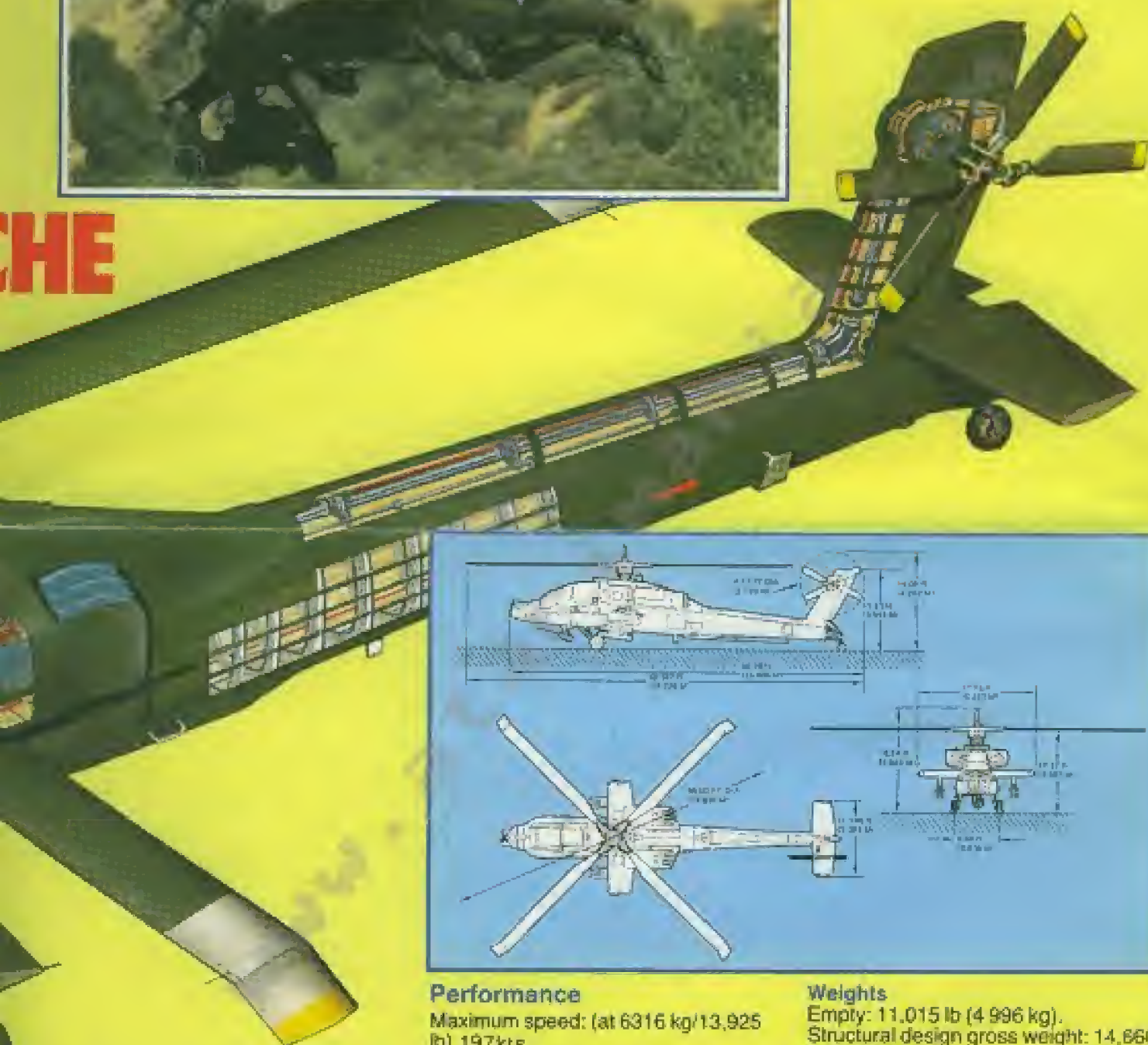
Dimensions
Main rotor diameter: 48' (14,63m)
Tail rotor diameter: 9' 2" (2, 79m).
Fuselage length: 49' 11½" (14,97m).
Height overall: 16' 9½" (3,84m)
Main rotor disc area: 1,809½ sq. ft.
(168.11^2).

Tomahawk by D.K. Marshall
Available on 48K Spectrum

Demonstrated performance
Based on actual flight test data, the AH-64A exceeds the Army's stated requirements by a factor of 3. Given primary mission requirements, vertical rate of takeoff has been demonstrated at 1450 FPM. A superior performance which gives the Apache substantial horsepower reserves and optimum tactical flexibility.

Performance
Maximum speed: (at 6316 kg/13,925 lb) 197kts
Max cruise speed: 158 kts.
Range: (internal fuel) 611 km (380 miles) and (ferry) 1804 km (1,121 miles).
Max. vertical rate of climb: 1450 ft. per minute.
Service ceiling: 20,000 ft. (6 100m).
Max. range internal fuel: 372 naut. miles (689 km).
Endurance: 1hr 50 min to 2hr 30min according to weapon load and mission profile.
Max. endurance on internal fuel: 3hr 34 min.

Weights
Empty: 11,015 lb (4 996 kg).
Structural design gross weight: 14,660 lb (6 650 kg).
Primary mission gross weight: 14,694 lb (6 665 kg).
Max. take-off weight: 17,650 lb (8006 kg).

AIR-TO-AIR COMBAT TECHNIQUES

To date, the "dogfight" scenario has rarely occured between helicopters but experts believe that there is a real possibility of air-to-air combat in future conflict, particularly with the most modern combat machines being equipped for the purpose.

Various techniques have been perfected by U.S. pilots, a few of which are described here for you to try.

High Yo Yo (Fig 1)

The objective of all manoeuvres is to position oneself on the tail of the threat aircraft, and to maintain this advantage until weapon release. The "High Yo Yo" begins with the enemy aircraft making a sudden tight turn in an attempt to break off the pursuit. By pulling up into a climb followed by a steep roll, turn and dive, the attacking helicopter prevents an overshoot and pulls out again onto the tail of the enemy aircraft.
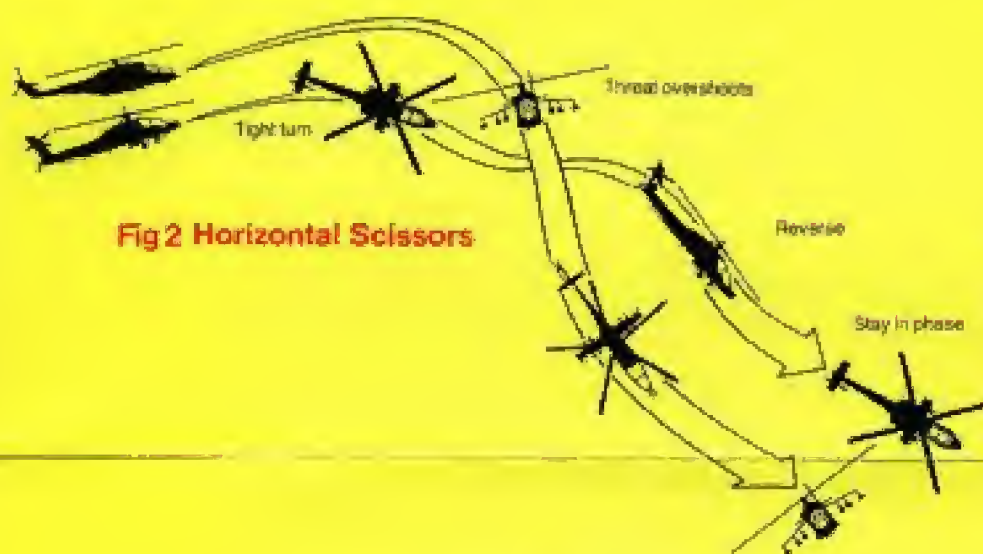
Fig 1 High Yo Yo

Fig 2 Horizontal Scissors

Horizontal Scissors (Fig 2)

This is a defensive manoeuvre intended to throw off a pursuing aircraft and subsequently come out onto his tail. Begin with a steep roll angle as if to enter a tight turn. As the enemy aircraft responds with his turn, quickly reverse the procedure to force the pursuer to overshoot. By rolling once again into a tight turn towards the enemy, the manoeuvre is completed.

Side-Flare Quick Stop (Fig 3)

This close-range defensive manoeuvre begins with a rapid deceleration brought about by brisk use of the rudder pedals to skew the helicopter. This gives an impression to the pursuing aircraft that you are entering a turn, when in fact you are slowing down rapidly. As he overshoots, the manoeuvre continues with a rapid acceleration (nose down, pull up on the collective) and a tight turn to bring yourself out onto the opponent's tail.

Defence against the side-flare is to perform a zoom climb followed by a torque turn, giving yourself a height advantage to begin a diving attack.
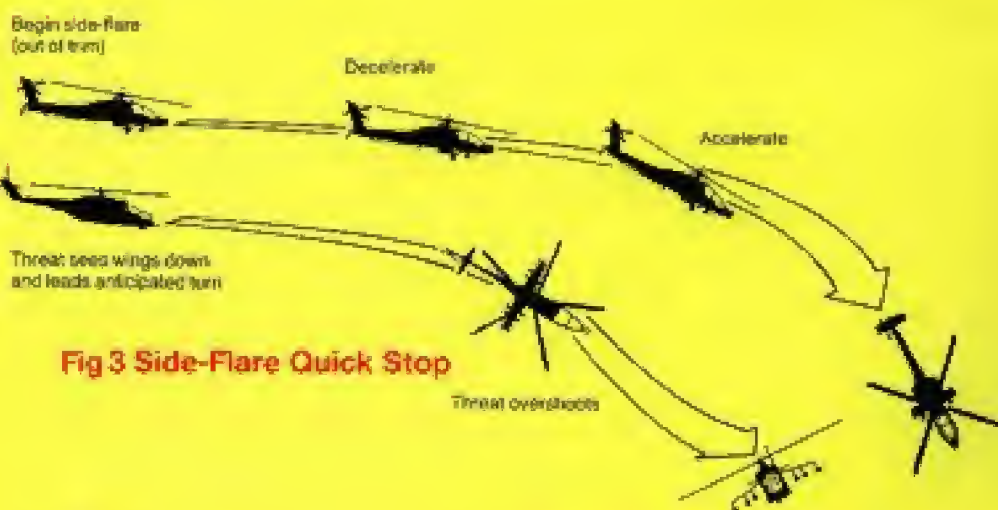
Fig 3 Side-Flare Quick Stop

Fig 4 Wing-Over Attack

Wing-Over Attack (Fig 4)

This offensive manoeuvre is used in a head-on approach situation and begins by accelerating towards the target, followed by a rapid climb to gain a height advantage. The attack continues with a steep turn or "wing-over", finally closing in for the kill. Defence against this manoeuvre begins with a climbing turn towards the attacking aircraft after he has committed himself to the closing attack. The outcome is usually a series of spiralling manoeuvres by both aircraft as each attempts to get onto the other's tail.

The unique agility of the helicopter offers enormous scope for very aggressive and spectacular combat manoeuvres. Practice makes perfect!

HELICOPTER AERODYNAMICS

The following description is intended only as an introduction to the subject. We recommend the following book for further reading:
"The Helicopter — history, piloting and how it flies" by John Fay, Published by David & Charles.

Lift, Weight, Thrust & Drag

Steady forward flight of any aircraft depends upon the balance of four forces — Lift, Weight, Thrust and Drag. In the case of the helicopter, Lift is generated by the rotor blades forcing air downwards as they rotate. In fact, each rotor blade is very similar to the wing of an aircraft with lift being generated by its aerofoil shape rotating at high speed. Variation of the lift is achieved by altering the angle at which the blade passes through the air, commonly known as the "angle of attack". If the pilot collectively tilts all of the rotor blades by the same amount, the resulting force will become greater than the weight of the helicopter and the aircraft will rise into the air. Finally, adjustment of the lift so that it equals the helicopter's weight will result in a steady hover. We have now balanced our first two forces — Lift and Weight. (Fig 1)

To begin forward motion, we must generate a forward force or Thrust. Unlike fixed-wing aircraft, helicopters do not use their engines as a direct source of forward thrust. The required force is generated by tilting the rotor blades thereby using a component of the vertical lift to pull the helicopter forwards. It is simple to imagine that the rotor blades would in fact act as a giant propeller if the helicopter were to tilt far enough forwards!

As the helicopter accelerates, an aerodynamic drag or wind resistance builds up to oppose the motion and eventually the helicopter's speed will stabilise so that the forward Thrust equals the aerodynamic Drag. We have now balanced our remaining two forces — Thrust and Drag. (Fig 1)

The helicopter however has an additional problem. The force required to turn the rotor blades generates an equal and opposite force (Newton's Third Law) tending to make the fuselage turn in the opposite direction to the rotor blades. This is overcome by introducing a tail rotor which pushes sideways and balances the unwanted reaction force.
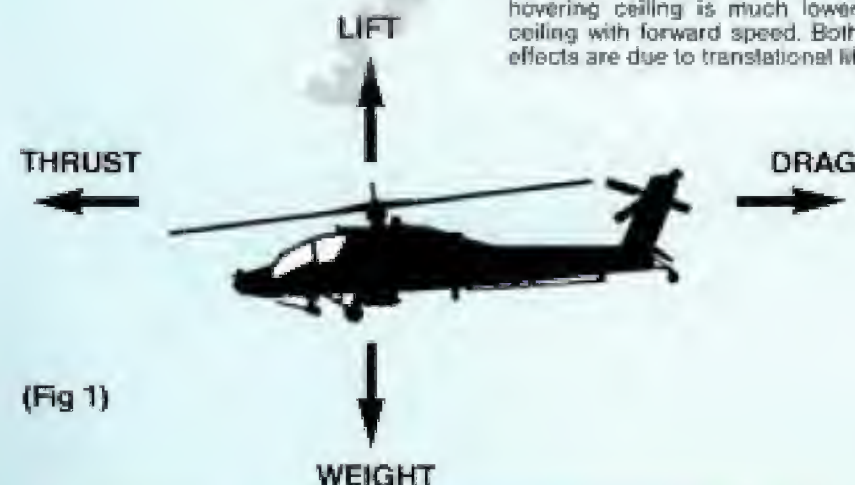
Pilot's Controls

The primary controls of a helicopter are similar to those found in a fixed-wing aircraft i.e. joystick and rudder pedals. The joystick or cyclic control column is used to tilt the fuselage of the helicopter up and down, and to roll the helicopter from side to side. Rudder pedals are used to turn or skew the helicopter by varying the pitch of the tail rotor blades. A third control, known as the Collective lever, is used to vary the pitch of the rotor blades "collectively" thereby giving a vertical lift control. Since forward thrust is derived from the main rotor blades, acceleration and speed control is achieved by a combination of cyclic and collective controls.

Unlike fixed-wing aircraft, operation of any one control usually results in the need to counteract unwanted responses with the other controls. In the case of the Apache however, much of this "cross-coupling" has been eliminated by automatic computer-controlled systems.

Since the engines are only providing power to rotate the rotor blades, it is typical in modern gas turbine helicopters to set and leave the throttle control at its maximum position. As the effort or "torque" required to drive the rotor blades varies due to blade pitch changes or aerodynamic effects, the power required from the engines varies accordingly. In order to keep the rotor blades turning at a constant speed, the power output from the engines is adjusted automatically by an "auto-throttle" which operates in parallel with the pilot's control. This considerably simplifies the task of flying the helicopter. Variations in power output from the engines can be seen as fluctuations in the engine rpm display on the instrument panel.

Translational Lift

The amount of lift generated by the rotor blades increases with helicopter speed. This is called "translational lift" and results in the pilot requiring less collective pitch as his speed increases. However, as the helicopter continues to accelerate, the extra lift generated is offset by the build up of large aerodynamic drag forces which in turn must be overcome with higher collective settings in order to maintain forward thrust. This variation in "operating efficiency" can be visualised as a curve with its peak at approximately 60 kts.

A helicopter requires much more power for a vertical climb than it does for the same rate of climb with forward speed. Also, its hovering ceiling is much lower than its ceiling with forward speed. Both of these effects are due to translational lift.

Limiting Speed

It is interesting to note what determines the limiting speed of a modern helicopter. Two factors contribute to a helicopter's top speed, both of which are associated with the aerodynamics of the main rotor blades. Firstly, the speed of the airflow over a rotor blade increases from its root to its tip simply because the tip speed is considerably faster than at the root. During each rotation, a blade will be advancing then retreating relative to the fuselage of the helicopter (Fig 2). As the helicopter flies forwards, part of the inner section of the retreating blade will be rotating in a rearwards direction at a speed which is lower than the forward speed of the helicopter. The airflow at this part of the blade will be passing backwards over the aerofoil and consequently unable to generate any lift. As the helicopter's speed increases, this loss of lift will spread out towards the tip of the retreating blade, which by now is the only part producing any lift. To achieve high forward speed, we have already seen that the pilot must increase the angle of attack of each rotor blade in order to generate the necessary forward thrust. The limiting speed of the helicopter is reached when the angle of attack becomes so great that the tip of the blade stalls, resulting in total loss of lift and severe vibration.

Secondly, as the speed of the helicopter increases, the speed of the advancing rotor blade will approach the speed of sound and begin to suffer aerodynamic compressability effects.

(Fig 2)

Ground Cushion

When hovering close to the ground, the downwash from the rotor blades tends to build up a cushion of air commonly called "ground cushion". This has the effect of increasing the effective lift, particularly useful with heavier take-off weight or at altitude where the air is less dense. It is possible to fly forwards whilst maintaining the ground cushion in order to build up some translational lift. The effectiveness of ground cushion decreases however with forward speed.

(Fig 1)

APACHE

Introduction

The primary role of the Apache is to attack and destroy hostile armoured vehicles with maximum surprise and with maximum safety for its crew. This must be achieved under the most adverse weather conditions, day or night, even after suffering significant battle damage. Despite a demanding specification from the U.S. Army, the Apache surpassed all expectations.

Development

Its design began in response to the U.S. Army requirement for a new Advanced Attack Helicopter. A contract was awarded to Hughes in June 1973 to build two prototypes, the first of which flew on 30th September 1975. Following a competitive fly-off against the Bell Model 409, the Hughes prototype AH-64 was selected for further development.

Subsequent modifications in Phase 2 included extension of the main rotor mast upwards by 9.5in to prevent the blades making contact with the fuselage which was happening under certain manoeuvres! The tailplane was moved from the top of the fin to the base of the tailcone to improve handling qualities. Three more prototypes were built with modifications including a further extension to the main rotor mast, swept back tips to the main rotor blades, a 3in increase in the tail rotor diameter, and the introduction of the "Black Hole" exhaust coolers. Development continued with a full evaluation of all weapon systems and avionics. The introduction of computer-controlled variable incidence tailplane

solved many unsatisfactory characteristics across the complete flight envelope.

Delivery of the first production Apaches to the Army took place in 1984 with the Army's projected total requirement in the region of 515 Apaches. Cost in 1984: $7.8 million each. The Apache production plant is at Mesa, Arizona where they aim to manufacture 12 machines per month.

Performance

Agility or aircraft response to control inputs is fast and precise. The Apache will produce 100 deg/sec rate of roll at between 120 kts and 140 kts and a high instantaneous turn rate, allowing it to be manoeuvred briskly around obstructions at low altitude. Sloppiness and slow response typical of most helicopter flight controls are absent. In fact, pilots tend to over control until they adjust to its crisp response. Despite this, pilots appear to adapt to the Apache's handling characteristics surprisingly quickly.

Tilting sharply forwards out of the hover and pulling 100% torque, the Apache reaches 100 kts in 250 yards, equivalent to 0 to 60 mph within 4.6 seconds. An impressive acceleration for a machine weighing 6.5 tons!

True airspeed in level flight with normal maximum continuous power (approx. 65% torque) is 146 kts. Aerodynamic drag rises sharply above this speed, with 100% torque giving approximately 160 kts in level flight. The maximum speed in a dive (Vne) is 197 kts.

Capable of hovering on both engines at 65% torque and 106% from a single engine, the Apache crew can be confident to survive a single engine failure, even in the hover.

Avionics

The Apache contains thirteen on-board computers with built-in self-test and automatic fault detection. Many of the "black boxes" are duplicated in different parts of the aircraft to reduce vulnerability to enemy fire. Much of the avionic equipment is located in bays either side of the forward fuselage, visible as large external fairings. This includes secure VHF, UHF, AM & FM radio, Doppler navigation, strapdown attitude and heading reference system, automatic stabilisation & command augmentation system (DASE), passive radar warning, IR & radar jammers, chaff/flare dispensers and the laser detector.

(a) Flight Control System

The flight control system is designed to simplify the task of flying under stressful conditions. Pilots find the Apache easy to fly, even without autostabilisation. At the heart of the system is the Digital Automatic Stabilisation Equipment (DASE) which takes information from sensors around the helicopter and shapes the pilot's control inputs to optimise the aircraft's response for tactical flying. Many of the unwanted control cross-coupling effects typical of many helicopters have been eliminated by automatic compensation and turns are automatically coordinated above 60 kts.

More specifically, DASE takes rate, velocity & heading information from the Heading & Attitude Reference System, collects normal air data from the PACER system on the rotor mast, matches this data with the pilot's control inputs & drives the rotor servos accordingly. In this manner, DASE may be described as a "command-augmentation" system shaping the helicopter's response to the pilot's intentions, giving us an "intelligent" system whereby the pilot simply "requests" his manoeuvre and the system handles both transient & steady states automatically to achieve the desired result.

A moving tailplane or stabilator is continuously controlled by the DASE, maintaining the Apache fuselage in a level flight attitude from 30 kts to its maximum speed of approximately 160 kts. The stabilator eliminates the pronounced nose-down or nose-up attitudes often seen on many helicopters thus reducing crew workload and allowing them to concentrate on accomplishing the anti-tank & ground-attack roles of the Apache.

(b) Target Aquisition and Designation Sight (TADS)

This is a cluster of sensors mounted in a stabilised housing in the helicopter's nose to give both pilot and gunner a choice of how to view the outside world. The weapon-aiming displays are viewed through an eye-piece by the gunner, plus a

ITS HISTORY, DESIGN, AND DEVELOPMENT

small "heads-out" display on his instrument panel. The TADS may be swivelled 120 deg right or left, 30 deg up, or 60 deg down. FLIR (Forward Looking Infra-Red) is used for night time vision. Daytime TV (DTV) in the near infra-red band can penetrate smoke and haze, and Direct View Optics (DVO) give a coloured display with a maximum magnification of ×126 — capable of visually zooming-in on a target up to 3 miles away! All three systems have a choice of field of view.

The TADS will automatically track a target after locking on to it. The gunner will use the DTV laser to determine target range, in practice offsetting the laser to avoid detection by the target. The target will finally be illuminated by the laser just prior to impact of the Hellfire missile. The target may also be illuminated by a remote source e.g. ground infantry. The Apache is then able to "fire-and-forget" each missile and return to cover. An alternative approach also available to the gunner is for the Apache to pop up from behind cover, take a video recording of the battlefield, and pop down again. After studying the video, the gunner may select a number of targets and enter their coordinates into the target computer. Hellfire missiles may then be launched from behind cover, popping up briefly to laser spot the target in the last few seconds of flight.

The gunner may select from a range of symbology on the displays according to the type of weapon to be used. For the Hellfire missiles, the TADS is rotated to place a dotted outline around the target. This outline becomes solid when the missile launch parameters are satisfied. For gun firing, a simple static sight is used but corrections for range and crosswind are automatically superimposed by the weapon control system.

(c) Pilot's Night Vision System (PNVS)
A remarkable system available to both pilot and gunner is the Integrated Helmet & Display Sighting System (IHADSS). The pilot looks through a helmet-mounted television "monocle" to view the outside world projected life-size into his right eye.

Sensors in the pilot's helmet determine his head position and drive the cameras in the nose of the helicopter accordingly. The PNVS turret may swivel 90 deg left or right, up 20 deg and down 45 deg, with a field of view of 50 deg. Symbology on the display shows the pilot his direction of flight if different from his line of sight, and the picture is so clear he can even distinguish power lines — useful when flying aggressively at extremely low altitudes. By combining the functions of TADS and IHADSS, either pilot or gunner may aim his weapon system simply by looking at the target!

Weapons
The fuselage carries a stub wing fitted with four weapon attachment points or pylons. The inboard pylons are normally used to carry 8 Hellfire missiles, 4 per side. The outer pylons are fitted typically with 19-inch tube 2.75in. rocket pods, steerable by either crew member using their helmet-mounted sights.

(a) M230 Chain Gun
Mounted underneath the nose of the Apache is the 30mm M230 Chain Gun, controlled through a rotating turret. The complete assembly weighs 118lb. and has a rate of fire of 750 rounds/min. Capacity is 1200 rounds. The gun mounting is collapsible and forms part of the energy absorption process in the event of a crash. The gun may be aimed using either TADS or the helmet-mounted display.

(b) Hellfire Missiles
This 100lb supersonic missile has a range of over 3 miles and a variety of guidance systems. In the case of the Apache, the target is illuminated with a laser beam which is detected by the missile's homing head. The Apache is capable of carrying up to 16 Hellfires.

Typical mission configurations:
Anti-tank mission: 16 Hellfire missiles and 1200 rounds of ammo.
Ground support: 8 Hellfire missiles, 38 rockets, 1200 rounds of ammo.
Airmobile escort: 38 rockets and 1200 rounds of ammo.

Structure
The fuselage is a conventional semi-monocoque aluminium structure with fracture-tough materials, redundant load paths and oversized structural members to minimise effects of battle damage. The main rotor consists of four blades, each having five stainless steel spars lined with structural glass-fibre tubes, a laminated stainless steel skin and a composite trailing edge to give a multiple redundant structure. Tests have shown that the main rotors can survive a direct hit by a 23mm shell! Each blade is attached to the hub by elastomeric lead/lag dampers and offset flapping hinges.
The tail rotor arrangement is an unusual design with the blades mounted 55 deg apart. The uneven spacing gives optimum low noise levels.

Both crew are protected by armour plated seats. The energy-absorbing landing gear was designed for normal landings of up to 12 ft/sec. and heavy landings of up to 48 ft/sec.

Engines
Two General Electric T700-GE-701 turbo-shafts producing 1,695 s.h.p. each, mounted on either side of the main transmission. The wide separation offers additional survivability, minimising the risk of both engines being lost due to a single hit, and full twin-engined redundancy. The main transmission will operate for up to one hour after the loss of all lubricating oil! Fitted to the rear of each engine is a heat-exchanger known as a "Black-Hole". This is to reduce the temperature of the exhaust gases and minimise detection by infra-red homing missiles.

LOADING INSTRUCTIONS

COMMODORE 64

For the C128, choose C-64 mode as advised by the manufacturer. Please ensure that joystick is connected to port 2.
1 Insert the disk into a disk drive
2 Type LOAD "*",8,1 and press RETURN
3 Program will load to display title page
4 Select languages by pressing E for English, D for Deutsch or F for Français

ATARI

This program requires Atari 600XL/800XL/130XE machine with a minimum of 64K memory.
Please ensure that joystick is connected to port 2.
1 Turn off the computer and all peripherals except the disk drive
2 Remove cartridges. Hold down OPTION key
3 Switch on power. The program will load to display title page
4 Select languages by pressing E for English, D for Deutsch or F for Français

3D real-world display:

Features include landing pads, buildings, trees, transmission pylons, mountains, enemy tanks, field guns and helicopters. Ground texture is visible when flying below 500 feet to enhance the sensation of speed. It is possible, with practice, to fly between trees and mountain peaks.

MENU OPTIONS

MISSION 1 – FLYING TRAINING – Used for helicopter familiarisation and developing ground attack skills. Enemy ground forces will not return fire. Each sector contains 8 enemy targets, either field guns or tanks, giving a total of 1024 possible targets across the complete map. Proceed to an adjacent sector after destroying all targets in your present sector, either by flying directly or landing at a pad and using the joystick (method described later under MAP). Refuel and reload with ammunition as necessary.

MISSION 2 – COMBAT – This is a short mission involving the invasion of four allied sectors by enemy ground forces. By selecting the map mode, you will see the sectors in question, flashing to indicate the presence of hostile forces. Your mission is to liberate the four sectors by destroying the ground targets, each sector taking typically 10 minutes to clear. After destroying all targets the mission is completed by landing at the nearest helicopter pad and closing the throttle.

MISSION 3 – COMBAT – Surrounded totally by enemy territory, your mission is to liberate the entire map from enemy occupation. Each hostile sector becomes allied as the ground targets are cleared, thus allowing you to land and reload with weapons etc.

MISSION 4 – COMBAT – A strategic battle for occupation of the entire map. Your task is to support allied ground forces in their battle along the front line. As each sector is cleared of enemy ground forces, the front line will progress to the right until you have cleared a complete row.

Likewise, if the enemy succeeds in destroying your ground forces, the sector will become hostile territory and the front line will progress to the left. Once a row is completely liberated or occupied, it is out of the game.

n.b. in all COMBAT missions the enemy will fire back! The simplest approach is to use the laser-guided missiles to destroy the enemy as soon as possible, but points scored will be lower than using rockets or guns.

In the heat of the battle, care must be taken to avoid landing in enemy territory if you are damaged or need to reload or refuel. Check for enemy occupation before landing by inspecting the map.

DAY OR NIGHT – Daytime: horizon visible.
Nightime: no horizon, computer-enhanced infra-red imaging. (Pilots' Night Vision system.)
CLEAR OR CLOUDY – option for overcast sky with selectable cloudbase for instrument flying.
CLOUDBASE – selectable from 50 ft to 5000 ft.
CROSSWINDS & TURBULENCE – for the experienced pilot! Variable crosswind & turbulence effects.
PILOT RATING – TRAINEE
                              SQUADRON
                              INSTRUCTOR
                              ACE
The pilot rating is equivalent to difficulty level and varies potency of enemy. With each increase in pilot rating, the enemy's accuracy doubles!
SOUND ON or OFF.

INSTRUMENTS:
TADS

Target Acquisition & Designation System –
Used to identify and track tanks, field guns and helicopters, allied or enemy.
Includes range readout in feet when target is less than 10,000 feet away.

VDU – Visual Display Unit

Speed in knots, (yellow = forwards, cyan = backwards)

Altitude, feet
VSI – Vertical Speed, ft/sec (arrow UP = climb, arrow DOWN = descent)
TIME – Time to reach target, in hours and minutes (hashed if greater than 4 hrs, zero if less than 1 minute)
RANGE – autoranging navigation computer
Within 0.1 mls: resolution in feet
Within 4.9 mls: resolution in 0.1 mls
Over 5 mls: resolution 1 mile.

ARTIFICIAL HORIZON

Roll symbol & roll angle readout
Pitch indicator – nose up/down attitude
Sideslip indicator – sideways "drift"

DOPPLER NAVIGATION/COMPASS –

Readout of Heading, Bearing & Track.
Heading: direction in which the helicopter is pointing.
Track: flight path direction.
Bearing: heading required to point at objective.

Note: a helicopter can be pointing in one direction (Heading) but moving in a different direction (Track) e.g. sideways! Match the heading to the target bearing to intercept target. The flashing dot indicates relative bearing of target.

Four modes:
B: Beacon navigation (8 beacons)
H: Landing Pad guidance (4 pads per sector)
T: Ground target tracking (8 targets per sector)
Lightning symbol: enemy helicopter interception
Flashing symbol warns of approaching enemy
helicopter.

CONTROLS

THROTTLE – key W to open throttle
key S to close throttle

Controls engine/turbine rpm. Normally set to fully
open unless practising engine-off landings.
Assisted in flight by computerised autothrottle
control.

COLLECTIVE LEVER – key Q increases lift
key A decreases lift

This is basically a vertical lift control used for
take-off to the hover, and forward thrust control in
straight & level flight.

CYCLIC CONTROL

joystick forward tilts nose down
joystick back tilts nose up
joystick right to roll right
joystick left to roll left

RUDDER – key X to yaw right
key Z to yaw left

DOPPLER MODE

Key C selects between beacon mode (B), landing
pad mode (H), ground attack mode (T) or air-to-air
mode (lightning symbol) on DOPPLER/COMPASS
instrument. Hold down key to cycle through modes.
key N selects "next objective" in each mode:
        8 beacons (0 to 7)
        4 landing pads per sector (0 to 3)
        8 enemy targets per sector (0 to 7)
        1 enemy helicopter

WEAPON SYSTEMS & TARGET ATTACK

When in ground attack or air-to-air mode, the
weapons systems are activated. The helicopter
must be airborne to fire its weapons. Select
between gun, rockets or missiles using key P. The
gun & rockets are manual tracking only i.e. the
target must be in the sights when the weapon is
launched or for the TADS to operate. The missile
system locks on to any hostile target passing
through the sights & lock-on is depicted by a Solid
Square. Tracking is automatic if the target remains
on screen.

GUN – diagonal sights – range 2000 ft
1200 rounds 30mm ammunition, 750 rounds/min.
ROCKET – Vert/Horiz sights – range 4000 ft
38 unguided rockets (19 each side).

MISSILES – square sights – range 3.1mls
8 Hellfire missiles – laser guided, auto-tracking

FIRE BUTTON – on joystick

The time for a weapon to reach a target will depend
on how far the target is away. It is possible to locate
and destroy enemy targets in both map mode and
in cloud.

During combat, enemy fire is indicated by flak.
The screen will flash if the helicopter is hit.

Damage to helicopter systems is indicated on the
failure status panel and structural damage is
shown by the Doppler helicopter symbol flashing.

A third structural hit is fatal! The chances of
being hit by the enemy are decreased by swerving
during the attack. You have a total of 3 helicopters
per mission. Study the mission report for crash
evaluation and performance report.

If an enemy helicopter is approaching, a warning
symbol will be flashed on the Doppler instrument if
you are not in air-to-air combat mode. You are
advised to select air-to-air combat mode and
destroy the enemy helicopter before he gets too
close!

Scoring Scheme

Weapon	Target		
Used	Field gun	Tank	Helicopter
Gun	20	–	100
Rockets	10	20	50
Missiles	5	10	25
	Points Scored		

It is not possible to destroy a tank with the chain
gun. Destruction of allied forces will result in total
loss of score. Although it is much easier to hit a
target with a missile, fewer points will be scored.
The enemy will begin to fire back at a range
between 4000 and 5000 feet, making it much more
dangerous to use guns (range 2000 ft!) but the
points scored will be higher.

MAP

Use key M to select map or to return to normal
display. Your helicopter is shown by the flashing
symbol with a tail. Enemy helicopters are shown
without a tailplane. Beacons 0 to 7 are used for
navigation purposes.

By selecting MAP mode when sitting on any allied
pad, the helicopter may be moved to another allied
sector by using joystick.

This feature eliminates the need for lengthy
straight and level flight to visit each sector.

When training (Mission 1), all sectors are allied and
any landing pad may be used for refuelling,
rearming or repairs. All sectors contain enemy
tanks and field guns for target practice.

In combat missions, territory is distinguished by
blue (Allied) sectors and red (Hostile) sectors. A
flashing blue sector indicates the presence of
enemy forces in allied territory. Likewise, a flashing
red sector indicates the presence of allied forces in
hostile territory. You will be captured by the enemy
if you touchdown in hostile territory.

The destruction of all enemy forces in a hostile
sector will result in the sector becoming allied.
Likewise, if all allied forces in a sector are
destroyed, the sector becomes hostile.

The map is designed to "wrap around" at the
edges i.e. when flying off the map, the helicopter
will reappear at the opposite edge.

COMPLETION OF MISSION

A mission is completed when all enemy ground
forces have been destroyed and you have returned
safely to a landing pad. After touchdown, close the
throttle to bring the turbine and rotor rpm to zero. A
complimentary mission report will follow.

PILOT'S NOTES

The controls in a real helicopter are "proportional",
i.e. their effect is proportional to the displacement
from centre. It is not possible to implement this

feature on the joystick since it contains simple on/off microswitches. By making the effect of each control proportional to how long the joystick is held, a simple approximation to "real" controls has been achieved, i.e. momentary operation of the joystick for fine control, and hold to build up a rapid rate. This does however mean that the joystick must be operated repeatedly for manoeuvres such as a steady turn or to hold a steady pitch angle.

Helicopters are naturally unstable and difficult to fly without autostabilisation. The Apache is fitted with Digital Automatic Stabilisation Equipment (DASE) making it far easier to fly than most modern helicopters.

Take-off procedure:

1 Ensure that collective indicator is at minimum.
2 Select full throttle – key W – hold pressed until throttle indicator at maximum.
3 Wait for turbine rpm & rotor rpm to reach 100%.
4 Increase collective pitch by pressing key Q until lift-off occurs. VSI indicates vertical speed in ft/sec.
5 Reduce collective (key A) to achieve hover i.e. VSI = 0. The helicopter is now hovering above the helipad.
6 Turning on the spot is accomplished by applying left or right rudder (Z or X).

Transition to forward flight from hover

1 Increase collective (key Q) to between 80% to 100% Torque. Reduce collective (key A) if overtorque warning sounds.
2 Tilt nose of helicopter downwards (joystick forward) to between 15 and 30 degrees.
3 Speed will be seen to increase. Autostabilisers will slowly raise the nose of the helicopter to a level attitude.
4 Reduce collective (key A) to adjust for VSI = 0 ft/sec i.e. not climbing or descending.

The helicopter will now be cruising at a steady forward speed. The Apache is a very agile helicopter. From a stable hover, it can reach 100 kts in approx. 6 seconds by pulling 100% torque and tilting the nose downwards to approx. 30 deg.

Straight & Level Flight

Forward speed is related primarily to the torque setting & hence the collective lever setting, assuming the helicopter is not autorotating (explained later). Typical speed/torque settings are as follows:

Torque	Speed
44%	60 kts
60%	119 kts
75%	147 kts
100%	159 kts

These values will vary slightly with altitude and changes in helicopter weight resulting from fuel consumption and weapon release. The Apache is fitted with a computer-controlled stabilator which enables the helicopter to cruise at any speed with the fuselage level.

Turning Flight

Providing that the forward speed is greater than 60 kts, turning is achieved by simply banking left or right. Some vertical lift will be lost when banking and the helicopter will begin to descend. This may be counteracted by increasing the collective setting. The helicopter will tend to slow down in a turn unless the pilot dives to sacrifice height to maintain speed.

At speeds under 60 kts, the helicopter will tend to "drift" into the turn, shown by the sideslip ball at the bottom of the artificial horizon. Turns may be assisted by applying the rudder, but this will reduce forward speed.

Fluctuations in rotor rpm occur during a turn because of g force effects. The autothrottle will adjust the turbine rpm accordingly to keep the rotor rpm at approximately 100%.

Slowing down & returning to the hover

1 Gently raise the nose of the helicopter by pulling back on the joystick. The aircraft will begin to slow down and also climb. Maintain the nose-up attitude by repeatedly pulling back on joystick (gently!).
2 Reduce the rate of climb by reducing collective (key A) to keep VSI to approximately zero. As the forward speed drops below 60 kts, increase collective (key Q) to counteract sink rate. Allow nose of helicopter to return to level flight as speed approaches zero.
3 Adjust collective as required to achieve a VSI of zero. The helicopter should now be in a stable hover.
4 The helicopter will also slow down when turning, providing that it is not in a dive. Banking repeatedly left and right is another common method of slowing down.
5 Providing that the forward speed is less than 60 knots, the pilot may apply rudder to increase sideslip (sideways drift). The helicopter will slow down dramatically as a result of the large drag forces generated.

Landing

The helicopter may be landed from the hover (vertical descent) or at forward speeds of less than 60 kts.

(a) From hover: Lower the collective lever to maintain a steady rate of descent. Maximum VSI at touchdown = 12 ft/s. Ground cushion effect will be experienced below 30 ft, resulting in reduction of the descent rate.

(b) Rolling touchdown: With a forward speed of less than 60 kts, gently lower the collective lever to begin descent. Max VSI at touchdown = 12 ft/s. After touchdown, the helicopter will slow down and eventually stop. Steer on the ground by using rudder control.

Taxiing on ground

The helicopter may be taxied on the ground, up to a maximum speed of 60 kts, providing that the engine/rotor rpm are at 100%. Assuming that the helicopter is stationary, raise the collective lever to produce about 20% torque. Pushing forward on the joystick will accelerate the aircraft, and likewise pulling back will decelerate and eventually stop. Steer by using the rudder.

Refuelling/Rearming/Repairs

By landing or taxiing onto a helipad (not an enemy one!) the aircraft may refuel, reload with weapons, and be repaired. Once on the pad, close the throttle to bring turbine & rotor rpm to zero. The helicopter will be serviced and prepared for the next take-off immediately.

Backward & Sideways Flight

Starting from the hover, the helicopter may be flown backwards by raising the collective lever and raising the nose to approximately 10 deg. The speed readout will turn cyan to denote backward

flight. Keep the nose of the helicopter pitched up to sustain speed. Likewise, the helicopter may be flown sideways by rolling left or right and raising the collective lever. The speed readout does not show sideways speed and the pilot must watch the sideslip indicator below the artificial horizon in order to monitor sideways drift.

Torque Turn

This manoeuvre allows the pilot to perform a 180 deg turn with a dramatic climb & simultaneous turn.

With a forward speed of 100 kts or more, pull the nose of the aircraft up to approx 70 deg pitch. Hold this nose-up attitude until the speed drops to approx 60 kts. Release joystick & apply rudder until heading has changed by approx 160 deg. Release rudder, adjust roll to zero if necessary and accelerate with nose down attitude. During this manoeuvre, the helicopter will roll, pitch & yaw simultaneously, pulling out on a reciprocal heading.

Aerobatics

The Apache may be flown safely within the following limits: Pitch ± 90 deg
Roll ± 110 deg

Control response may become unpredictable outside these limits i.e. loops & rolls are NOT recommended!

Autorotation

Autorotation is equivalent to the helicopter "gliding" through the air and is used when the pilot wishes to descend rapidly or after engine failure. During autorotation, the rotor blades are being driven by airflow through the rotor disc as the helicopter descends. This reduces the power required from the engines and the engine RPM is automatically reduced to maintain 100% rotor speed and the "split" between turbine rpm & rotor rpm can be seen on the bar scales. Autorotation is best performed at approximately 60 kts. and above 500 ft. Entry into autorotation is made by gently lowering the collective lever:

(a) Engines active

As the descent rate builds up, the automatic throttle control will be seen to reduce the turbine rpm. Any fluctuations in rotor rpm will be compensated automatically by the autothrottle. As the altitude falls to below 200 feet, the pilot should begin to pull the collective lever up to reduce the rate of descent, accompanied by raising the nose of the helicopter if he wishes to slow down. With practice, the pilot will co-ordinate increasing the collective and adjusting the pitch angle in order to slow down to the hover just a few feet above the ground.

(b) Engine-off landings

In the event of failure of both engines or if the pilot deliberately closes the throttle in flight, engine rpm will reduce to zero. The pilot must respond quickly by lowering the collective lever before the rotor blades slow down too much. Rotor rpm is controlled during the descent by careful adjustment of the collective lever. Keeping the helicopter level and the speed between 50 & 60 kts, raise the collective lever just before touchdown to bring the rate of descent to below 12 ft/sec

Warnings – limits worth noting!

1. The maximum permissible speed of Apache is 197 kts. in a dive. If the speed should rise above this, the pilot will get an audible warning.

If he continues to increase his speed, the helicopter will shed a rotor blade at 210 kts, resulting in catastrophic loss of control!

2 If the pilot demands too much power from the engines (overtorque), an audible warning will occur. If this warning is ignored, the engines will eventually fail. It is possible to hover and fly on one engine but flying time is limited if both engines have failed!

Features of TOMAHAWK:

● Spectacular 3D real world display
● Fully aerobatic (within limitations of real helicopter)
● Ground attack & air-to-air interception
● Over 7000 ground features
● Day/night vision systems
● Cloudy conditions, crosswinds & turbulence
● Doppler navigation & target tracking system
● Laser guided missiles, plus rockets & 30mm chain gun
● Selection of training and combat missions
● Pilot ratings – Trainee to Ace

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SUMMARY OF CONTROLS

	Roll Left	joystick left
	Pitch UP	joystick back
	Pitch DOWN	joystick forward
	Roll RIGHT	joystick right
Z	LEFT rudder	
X	RIGHT rudder	
C	Change mode of Doppler	
N	Next objective	
P	Select weapon system	
Q	Increase collective	
A	Decrease collective	
W	Open THROTTLE	
S	Close THROTTLE	
M	MAP	
H	Pause	
J	Continue	

CONTROL – RETURN to Abort mission & return to menu.

INSTRUMENT PANEL NOTATION

1 Collective lever
2 Torque % (a) Engine 1 (b) Engine 2
3 RPM % (a) Engine 1 (b) Rotor blades (c) Engine 2
4 Throttle indicator
5 TADS – Target Acquisition & Designation System
6 Fuel level
7 Pilot's Visual Display Unit
8 Speed, in knots (yellow = forwards, cyan = backwards)
9 Altitude, in feet
10 Time to objective, hours & mins
11 Vertical speed indicator, VSI, feet per sec
12 Distance from objective, in feet or miles
13 Artificial Horizon
14 Roll symbol
15 Roll angle
16 Pitch angle
17 Sideslip (drift) indicator
18 Doppler
19 Navigation/Compass Heading
20 Bearing
21 Track
22 Engines) Failure Status Panel
23 Weapons)
24 Nav computer)
25 TADS)
26 Score
27 30mm chain gun ammo supply
28 Rockets
29 Hellfire Missiles

INSTRUMENT PANEL
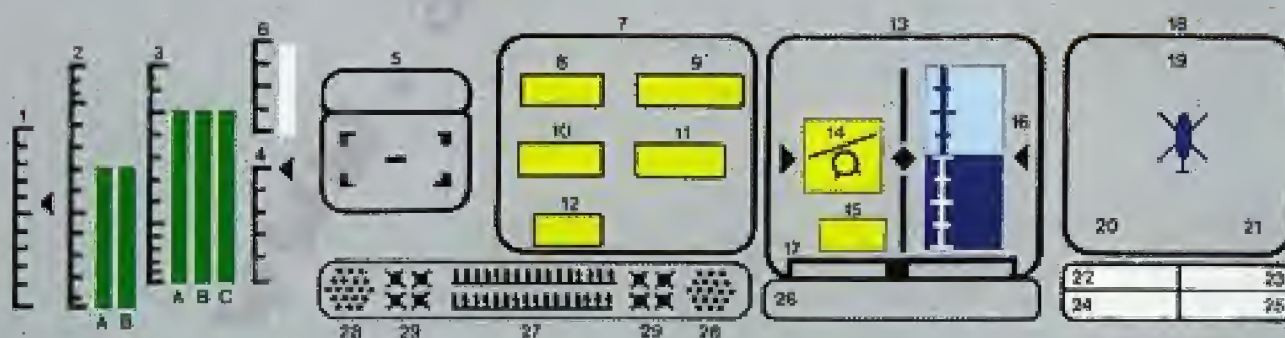
ÜBERSICHT/ANGABE DER STEUERGERÄTE

Nach links rollen	Steuerknüppel nach links
Steigungssteuerung erhöhen	Steuerknüppel zurück
Steigungssteuerung senken	Steuerknüppel nach vorne
Nach rechts rollen	Steuerknüppel nach rechts

Z LINKES Steuerruder
X RECHTES Steuerruder

C Dopplermodus Wechsel
N Nächstes Ziel
P Waffensystem wählen
Q Nichtperiodische Steigungssteuerung erhöhen
A Nichtperiodische Steigungssteuerung senken
W Vergaser öffnen
S Vergaser schließen
M Karte
H Pause
J Fortsetzen

STEUERUNG – RÜCKKEHR um den Einsatz abzubrechen & und zu dem Menü zurückzukommen

INSTRUMENTENTAFEL DARSTELLUNG

1 Nichtperiodische Steigungssteuerung
2 Drehmoment % (a) Motor 1, (b) Motor 2
3 RPM % (a) Motor 1, (b) Rotorblätter, (c) Motor 2
4 Vergaseranzeiger
5 TADS – Zielerfassungs – und Bezeichnungssystem
6 Kraftstoffstand
7 VDU – Bildsichtgerät des Piloten
8 Geschwindigkeit in Knoten
9 Höhenlage, in Fuß
10 Zeit bis Ziel, Stunden & Minuten
11 VSI – vertikaler Geschwindigkeitsanzeiger
12 Entfernung vom Ziel, in Fuß oder Meilen
13 Künstlicher Horizont
14 Rollezeichen

15 Rollewinkel
16 Längsneigungswinkel
17 Schiebefluganzeiger (Abtrift)
18 Dopplernavigation/Kompass
19 Steuerkurs
20 Peilung
21 Kurs
22 Motore)
23 Waffen)
24 Nav Computer) Störungsmeldetafel
25 TADS)
26 Spielstand
27 30mm Kettengeschütz Munitionsversorgung
28 Raketen
29 Hellfire Lenkwaffen

RECAPITULATION DES COMMANDES

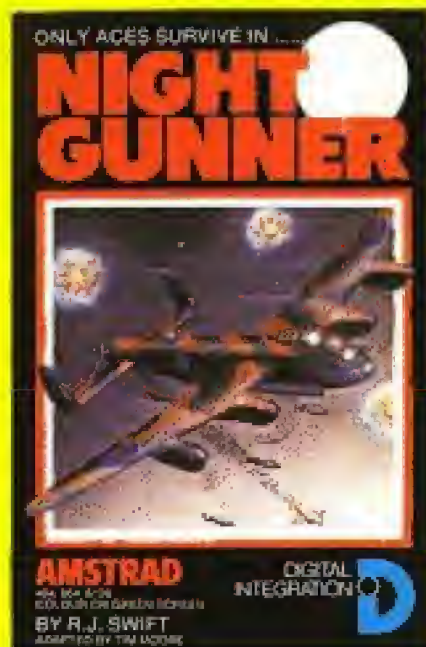|	
Roulis vers la gauche	manche vers la gauche
En cabré	manche vers l'arrière
En piqué	manche vers l'avant
Roulis vers la droite	manche vers la droite

Z Gouvernail de direction vers la GAUCHE
X Gouvernail de direction vers la DROITE
C Modifier mode de Doppler
N Objectif suivant
P Sélection systeme armement

Q Augmente pas général
A Diminue pas général
W Ouvrir MANETTE
S Fermer MANETTE
M CARTE
H Pause
J Pour continuer

CONTROL – RETURN Abandon de la mission et retour au menu

NOMENCLATURE DU TABLEAU DE BORD

1 Levier de pas général (collectif)
2 Couple % (a) Moteur 1, (b) Moteur 2
3 Regime % (a) Moteur 1, (b) Pales de rotor, (c) Moteur 2
4 Position de la manette
5 SADC – Systeme d'Acquisition et de Designation du Cible
6 Niveau carburant
7 Unité affichage pilote
8 Vitesse en noeuds
9 Altitude en pieds
10 Temps nécessaire pour atteindre objectif, heures/minutes
11 Variomètre (indicateur de vitesse verticale), pieds par seconde
12 Distance de l'objectif, en pieds ou milles.
13 Horizon artificiel

14 Symbole de roulis
15 Angle de roulis
16 Angle de pente
17 Indicateur de dérapage (dérive laterale) (niveau Vinot)
18 Doppler
19 Navigation / boussole Cape
20 Gisement (azimut)
21 Cap (parcours)
22 Moteurs)
23 Armes)
24 Ordinateur) Tableau état defauts
25 navigation)
   SADC)
26 Compte des points
27 Alimentation munitions pour canon à chaine 30 mm
28 Fusées
29 Missiles Hellfire